AD NUMBER
AD013850
CLASSIFICATION CHANGES
TO: **unclassified**
FROM: **confidential**
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Controlling DoD Organization: Naval Ordnance Lab., White Oak, MD.**
AUTHORITY
Naval Ordnance Lab ltr dtd 29 Aug 1974; Naval Ordnance Lab ltr dtd 29 Aug 1974

CONFIDENTIAL

NAVORD REPORT 2762

13850

REPORTS ISSUED BY EXPLOSIVES RESEARCH DEPARTMENT DURING CALENDAR YEAR 1952

29 JANUARY 1953

U. S. NAVAL ORDNANCE LABORATORY

WHITE OAK, MARYLAND

CONFIDENTIAL

SECURITY INFORMATION

REPORTS ISSUED BY EXPLOSIVES RESEARCH DEPARTMENT DURING CALENDAR YEAR 1952

By:
Russell McGill

Approved by: J. E. Ablard
J. E. ABLARD, Deputy Chief
Explosives Research Department

ABSTRACT: The written reports issued by the Explosives Research Department and addresses or lectures given by members of the Department are listed herein. Abstracts of the reports are given in order to enable the reader to determine whether the complete text would be of value. The Laboratory will be pleased to furnish copies and additional information. Requests for information about Technical Notes should be marked for the attention of their authors.

EXPLOSIVES RESEARCH DEPARTMENT
U.S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

NAVORD Report 2762 29 January 1953

This report presents titles of reports issued during the calendar year 1952 by the Explosives Research Department together with summaries of their texts. The accuracy of the work and responsibilities of the authors and the Division are defined in each report. This report was written to improve the availability of the information contained in the documents.

EDWARD L. WOODYARD
Captain, USN
Commander

J. E. Ablard

J. E. ABLARD
By direction

TABLE OF CONTENTS

	Page
INTRODUCTION	1-2
ABSTRACTS OF NAVORD REPORTS	2-21
ABSTRACTS OF TECHNICAL NOTES	22-28
ABSTRACT OF NOLR	28-29
ABSTRACTS OF PAPERS PRESENTED AT TECHNICAL SOCIETY MEETINGS	29-32
AUTHOR INDEX	33-40
SUBJECT INDEX	41-59

REPORTS ISSUED BY EXPLOSIVES RESEARCH DEPARTMENT DURING CALENDAR YEAR 1952

INTRODUCTION

Abstracts of reports issued by the Explosives Research Department during the calendar year 1952 are compiled herein. It is hoped that the information given will enable the reader to decide whether to obtain the complete report for further study. Most of the reports have been given rather wide distribution, and are available at facilities having copies of this report. If this is not the case, or if additional details are desired, the reader is advised to communicate with the Naval Ordnance Laboratory.

Technical Notes, abstracts of which are included, are not approved for distribution outside the Naval Ordnance Laboratory. If more complete or detailed information is desired it may be requested by letter to or in conference with the author(s).

Nearly all the abstracts were copied from the individual reports with only minor revision by the author of this report. Several exceptionally long abstracts were reduced in length by deletion. All reports are classified Confidential unless noted otherwise.

The organization of the Explosives Research Department may be outlined as follows. The Chiefs of the Department and Divisions are given together with a statement about the activities of the Divisions:

Dr. Paul M. Fye, Chief, Explosives Research Department
Dr. James E. Ablard, Deputy Chief, Explosives Research Department

Chemistry Division, Chief, Dr. Darrell V. Sickman

Responsibility for investigating the chemistry of explosives, and their stabilities, especially new explosives, is assigned to this Division.

Detonation Division, Chief, Mr. Sigmund J. Jacobs

The staff of this Division investigate detonation phenomena such as rates, shaped charge effects and fragmentation.

Explosion Effects Division, Chief, Dr. Wilford E. Morris, Acting Chief, Mr. James F. Moulton

This Division is concerned with air blast and damage effects in air.

Fuels and Propellants Division, Chief, Dr. Evan C. Noonan

Investigates fundamentals of ignition of propellants, thermal decomposition of propellant ingredients, liquid monopropellants and explosives; and thermodynamic properties of gases at high temperatures and pressures.

Explosion Hydrodynamics Division, Chief, Dr. Elijah Swift, Jr.

This Division is concerned with underwater explosions and particularly how explosives cause underwater damage.

Explosives Properties Division, Chief, Dr. Russell McGill

Explosive phenomena are investigated by small scale techniques, sensitivity to impact and shocks are studied, and experimental explosive charges prepared for use by the Explosives Research Department and others.

Ordnance Applications Officer, LCdr. J. D. McClendon, USN

Assistant Department Chief for Atomic Tests, Mr. Casper J. Aronson

ABSTRACTS OF NAVORD REPORTS

NavOrd Report 1804
Heat Capacities for Calculations of Explosion Phenomena, 1 May 1952, M. J. Fischer and H. G. Snay

High temperature heat capacity data for the ideal state which are suitable for thermodynamic calculations of explosion phenomena are presented for 42 gaseous and solid compounds or elements. The data are given as coefficients of the well known two or three term approximations for the relationship between heat capacity and temperature. They are adapted to the temperature range of explosions by extrapolations using spectroscopic data and other methods. Tables are included for the standard entropy, heat of formation and the standard equilibrium constant.

The second part deals with the mean heat capacity for an isentropic change of state. A rigorous expression for this magnitude can be derived for temperature, pressure and specific volume along an isentropic. Here, it is shown by means of numerical comparisons that this expression is a good approximation also for the Riemann function, specific enthalpy and sound velocity along an isentropic.

NavOrd Report 2167
A High Speed Recording System Using the Velocity Method to Determine the Peak Pressure Produced in Air by Explosives, 25 February 1952, P. Z. Kalavski, Unclassified

This report has been written to describe a high speed recording system for determining peak pressures in the 5-90 psi pressure range from explosions in air by the velocity method. This equipment is now in use in the Mobile Air Blast Laboratory at Stump Neck, Maryland.

A brief review is given of the theoretical basis for determining peak pressure by measurement of shock and sound velocities. A description is given of the function of each component of the equipment, from the gage to the camera. The chronological sequence of events is described. A typical record is illustrated and the method of analysis is described. Circuit diagrams are included for all units of the recording system. The accuracy limitations of the recording system are discussed.

The standard deviation using this equipment varies from two per cent at low pressures to seven per cent at high pressures. Suggestions for future improvements are included, based on the operation of this velocity recording system.

NavOrd Report 2277
The Effect of Aluminum on Underwater Explosive Performance: Bubble Pulse Parameters from 1-Lb Charges, 1 January 1952, E. A. Christian, J. A. Goertner, J. P. Slifko and E. Swift, Jr.

Pressure-time recordings were made of the bubble pulses from 1-lb charges of RDX/TNT/Al mixtures. The percentages of aluminum were varied from 0 to 45%, with HBX-1 and HBX-3 compositions included. It was found that as aluminum content increases, the bubble pulse peak pressure and energy decrease, the positive duration increases, and the positive impulse remains relatively constant. Total bubble energy, as represented by the cube of the first bubble period constant, increases with increasing aluminum.

NavOrd Report 2301
Spin Table for Calibrating Accelerometers, 14 January 1952, R. G. Quick, Unclassified

The design, construction and operation of a spin table or rotary accelerator for calibrating horizontal and vertical accelerometers within the range of 0.1g to 55g are described in this report. Accuracies of ± 2% and resolution of 0.002g have been obtained under field conditions. The design is relatively light in weight and intended for carrying loads up to two pounds.

NavOrd Report 2313
A Kinetic Study of the Thermal Decomposition of Ethyl Nitrate, 12 June 1952, J. B. Levy, Unclassified

The thermal decomposition of ethyl nitrate in the vapor phase has been studied at 161-201°C and pressures below 200 mm Hg. An analytical technique has been developed using the infrared spectrometer and the ultraviolet spectrophotometer which has made it possible to follow the disappearance of ethyl nitrate directly.

It has been found that ethyl nitrite is an important reaction intermediate. The formation and disappearance of ethyl nitrite and of nitrogen dioxide over the course of the reaction have been followed using the new techniques. The effect of nitrogen dioxide, ethyl nitrite and mercury on the reaction have been studied.

The mechanism of nitrate ester decomposition is examined in the light of the results found in this work.

NavOrd Report 2317
The Effect of Aluminum on Underwater Explosive Performance: Shock Wave Parameters from 1-Lb Charges, 1 January 1952, R. W. Astheimer, E. A. Christian, and E. Swift, Jr.

Pressure-time recordings were made of the shock waves from 1-lb charges of RDX/TNT/Aluminum mixtures. The percentage of aluminum was varied from 0 to 45%, with HBX-1 and HBX-3 compositions included. Equivalent weight ratios were obtained with UERL diaphragm gages and first bubble periods were measured. It was found that with increasing aluminum content, the shock wave parameters show broad maxima of p_m at 10-15% Al, impulse at 25-30% Al and energy at 20-25% Al. Total bubble energy, as represented by the cube of the first bubble period constant, increases with increasing aluminum. Equivalent weights found from the UERL diaphragm gages are in good agreement with those calculated from the piezoelectric gage measurements of shock wave energy.

NavOrd Report 2322
The Van der Waals Laboratory of Amsterdam, 3 March 1952, Donna Price, Unclassified

This report describes a survey, by the writer, of high pressure operations and equipment at the Van der Waals Laboratory. The information which was obtained is to be used by the thermodynamic group in the Explosives Research Department for making similar studies of gases at high pressure with the aid of equipment of the Van der Waals' design.

NavOrd Report 2339
Reports Issued by Explosives Research Department During Calendar Year 1951, 21 February 1952, Russell McGill

The written reports issued by the Explosives Research Department and addresses or lectures given by members of the Department are listed herein. Abstracts of the reports are given in order to enable the reader to determine whether the complete text would be of value.

NavOrd Report 2348
The Determination of the Optimum Air Blast Mixture of Explosives in the RDX/TNT/Aluminum System, 12 March 1952, E. M. Fisher

Twenty-seven different mixtures of RDX, TNT, and Aluminum were studied to determine the optimum air blast mixture on the basis of peak pressure and positive impulse. Comp B, TNT, HBX-1, HBX-3, Tritonal, and H-6 were included in the survey.

NavOrd Report 2368
The Effect of Aluminum on Underwater Explosive Performance: Shock Wave Parameters from 50-lb Charges, 1 March 1952, J. A. Goertner, E. A. Christian and J. P. Slifko

The underwater shock wave parameters for four mixtures of RDX, TNT and aluminum are compared. Six 50-lb charges of each were fired, and peak pressure, time constant, momentum and energy of the shock wave were measured. The results are presented on an equal weight basis and on an equal volume basis.

NavOrd Report 2369
Spalling Produced by Detonation of Explosives in Very Heavy-Walled Metal Tubes, 18 March 1952, L. E. Starr, and J. Savitt, Unclassified

A method is described for obtaining experimental compression wave velocities in metals. Measurements of the shock wave velocity in copper were made and found to be in good agreement with theoretical predictions. An explanation for the discrepancy between the wave velocity in copper reported by Rinehart and Pearson, and the velocity

reported in this report is presented.

NavOrd Report 2370
Booster Sensitivity Investigations During the Period from July 1949 to March 1952, 20 March 1952, C. C. Lovenberg

The work on the Naval Ordnance Laboratory version of the "Booster Sensitivity Test", for a three year period is summarized. Booster sensitivity determinations are recorded for many varied compositions some of which have been reported previously in comprehensive reports dealing with complete evaluation of the material under consideration. The routine test procedure is described briefly.

NavOrd Report 2375
Detonation Velocity Measurements of Certain Linear Polymethylenepoly-nitramine Explosives, 26 March 1952, L. D. Hampton

Measurements of the detonation velocities of several explosives prepared by the Naval Ordnance Test Station, China Lake, California and sent to the Naval Ordnance Laboratory for evaluation are reported. Detonation velocities of mixtures of these materials with RDX and HMX analogous to Comp A and Comp B are given. The detonation velocities of the Comp A analogue were found to be very near to those of Comp A. The Comp B analogue had a velocity which was somewhat higher than that of Comp A.

NavOrd Report 2380
A High-Speed High-Pressure Gage, 12 May 1952, P. L. Edwards, Unclassified

The design and tests of a pressure gage for the measurement of high speed transient pressures up to 100,000 psi is described. The gage consists of a thin x-cut quartz crystal cemented to a steel plate. The pressure deforms the plate and strains the crystal, thereby producing an electrical signal which is a function of the pressure. The frequency response tests and calibration procedures are described. The lowest natural frequency was found to be about 80,000 cps with a damping 2% of critical. The gage sensitivity is such that 10,000 psi pressure produces a signal of one volt across 1,000 micromicrofarads.

NavOrd Report 2383
Shock Wave Parameters in Fresh Water for Pressures up to 95 Kilobars, 1 April 1952, H. G. Snay and J. H. Rosenbaum, Unclassified

The propagation velocity of a shock front in fresh water, and the particle velocity, sound velocity, specific volume, and temperature immediately behind the front, are calculated from PVT data not heretofore considered. These data, due chiefly to Bridgman, extend up to 36,500 kg/cm^2 for water and up to 50,000 kg/cm^2 for ice VII.

Extrapolations are made up to 100,000 kg/cm^2 for both ice VII and the supercooled liquid. In the calculation of the shock wave parameters, both supercooling of the liquid and instantaneous equilibrium along the water-ice VII phase line are considered.

NavOrd Report 2384
Evaluation of Bis(Trinitroethyl)Nitramine as a Substitute for Cyclotrimethylenetrinitramine (RDX) in Composition A, 15 April 1952, C. C. Lovenberg, and G. Svadeba

Bis(trinitroethyl)nitramine, designated BTNEN, has been produced in sufficient quantity to permit fairly extensive evaluation as a military explosive. The preliminary evaluation of BTNEN as a substitute for RDX in Comp A-3 was done by the Explosives Properties Division. BTNEN, in common with a number of other explosives including RDX, is too sensitive to mechanical shock to be acceptable as a military explosive. BTNEN was combined with at least 60 different candidate desensitizers, and in some cases by several methods. Unfortunately stable BTNEN compositions which could be expected to compare favorably with Comp A-3 as an explosive, and which were satisfactorily desensitized were not obtained.

Evaluation of BTNEN Comp A-3 analogue was then undertaken without awaiting successful desensitization of the BTNEN. A Comp A-3 analogue containing 90% BTNEN and 10% Carnauba wax was selected for evaluation, because the results would be comparable with the results obtained from evaluation of the BTNEU/Aristowax 90/10 Comp A-3 analogue.

The booster sensitivity of the BTNEN/Carnauba 90/10 Comp A-3 analogue was found to be higher than that of Comp A-3 and the BTNEU/Aristowax Comp A-3 analogue. The relative brisance was found to be higher than BTNEU/Aristowax Comp A-3 analogue and Comp A-3.

NavOrd Report 2385
Investigation of the Propagation of Detonation Between Small Confined Explosive Charges, Progress Report, 1 April 1952, W. E. Dimmock, Jr., L. D. Hampton, and L. E. Starr

Studies of the propagation of detonation between small confined charges in which the donor charge is dextrinated lead azide, and the acceptor charge is tetryl are reported. They include a study of propagation through aluminum barriers, studies of the effect of confining media of the donor and acceptor, and a study of the sensitivities of different lots of tetryl. The thickness of aluminum through which detonation was propagated was about two-thirds of the air gap across which propagation was obtained under similar conditions. Brass, steel, and aluminum were used as confining media in the donor. The gap, across which detonation was propagated fifty per cent of the time, was

significantly greater when brass or steel was used as the confining media. When used in the acceptor, steel and copper were more effective confining media than aluminum and its alloys. The study of the sensitivity of tetryl indicates that smaller particle size tetryl is more sensitive to initiation than less finely divided explosive. A wide range of sensitivities was found between different batches and lots of tetryl. A microscopic examination failed to reveal any characteristic which could be correlated with this change in sensitivity.

NavOrd 2394
A Preliminary Investigation of the Decomposition of BTNEN in Water, 9 April 1952, D. W. Jensen

BTNEN, bis(2,2,2-trinitroethyl)nitramine decomposes in water to produce nitroform, nitrogen oxides, carbon dioxide and ammonia slowly at room temperature and more rapidly when heated. The decomposition proceeds much more rapidly in dilute alkali.

NavOrd Report 2422
Small Scale Plate Dent Test for Confined Charges, 23 April 1952, W. M. Slie, and R. H. F. Stresau

Brisance tests of small diameter highly confined charges of pure explosive compounds have been made. The diameter of the confined charge varied from one-tenth inch to one-quarter inch. The experiments indicated a nearly linear relationship between the total brisance measured by the depth of the dent, and the detonation velocity. An expression relating the depth of dent for confined charges to properties of the explosive and the metal used has been developed. The results indicated that small scale brisance tests may be used to estimate whether new explosive compounds would be superior to those in use in ordnance.

NavOrd Report 2433
Sensitivity of Explosives to Impact Period, 1 August 1951 to 1 May 1952, 5 May 1952, G. Svadeba

Impact sensitivity data of all explosive compounds and mixtures tested by the Explosives Properties Division of the Explosives Research Department during the period 1 August 1951 to 1 May 1952 are included in this report with two exceptions. Impact tests on desensitized BTNEU and BTNEN samples have been reported NavOrd Report 2287 and NavOrd Report 2384 respectively. The results in this report have been divided into two categories, one of which is the test of samples prepared by various contractors in connection with the Navy's new high explosive program. The other category includes all special tests made for Divisions of the Department and Bureau of Ordnance. The type of machine and tools employed, the basic test procedure, method of treating data and the preparation of samples are described.

NavOrd Report 2436
The Formation of a Water Column by an Explosion in Very Shallow Water, 1 July 1952, J. H. Rosenbaum, and H. G. Snay, Unclassified

A theory is developed which describes the formation of an expanding water column under idealized conditions. It is assumed that the column has vertical walls and consists of a coherent uniform fluid. In the derivation, forces due to the upward acceleration of the water particles are included. The final expressions are solved numerically for a special case. In the Appendix, a less exact theory is derived, which is based on the non-linear shallow water theory and thus ignores forces due to vertical particle acceleration. A numerical solution of this case is compared with the results of the more exact theory.

NavOrd Report 2437
Underwater Explosion Phenomena: The Parameters of a Non-Migrating Bubble Oscillating in an Incompressible Medium, 1 February 1952, H. G. Snay, and E. A. Christian, Unclassified

A number of functions, which avoid much laborious computation in the practical application of the incompressible theory of explosion gas bubbles, are derived and tabulated. Examples of the uses of these functions are given. Some of the values of specific bubble parameters are extended to a wider range of conditions than was previously covered.

NavOrd Report 2442
Recent Air Shock Velocity Measurements Near Small Charges of Highly Confined Explosives, 12 May 1952, J. Savitt, and R. H. F. Stresau, Unclassified

Recent results of air shock velocity measurements near small charges of highly confined primary and high explosives are described and compared. A dependence of air shock velocity produced by high explosives upon the explosives loading density was observed very near to the explosive air interface. The velocity of the air shock produced by lead azide is found to depend upon the length of the explosive column as well as its loading density.

NavOrd Report 2445
Radiation Measurement of High Transient Temperatures, 9 June 1952, D. Price, Unclassified

This report discusses the measurement of high transient temperatures of a gas at about 116,000 psi and 3870°K; the expected duration of these maximum conditions in an adiabatic compressor is 80 microseconds or less. The proposed method is based on the assumption that the high density, hot gases will approximate a solid radiator under these conditions. Definitions of temperatures which can be measured and the required

information of emissivity behavior to relate the measured to the true temperature are discussed.

Reviews of the emissivity of radiation standards - particularly of tungsten - and of work on gas emissivities which has been carried out on gases at much lower pressures are presented. In view of the present information and assumptions, the experimental program necessary for the measurement of high transient temperatures is outlined.

NavOrd Report 2448
The Preparation and Properties of Bis(2,2-Dinitropropyl)Nitramine, 6 June 1952, O. H. Johnson

A new high explosive compound, bis(2,2-dinitropropyl)nitramine, DNPN, has been prepared and subjected to preliminary study. It possesses excellent thermal stability at elevated temperatures, and a density and impact sensitivity essentially the same as those of tetryl. Gap sensitivity measurements indicate that it is slightly harder to initiate than tetryl, but produces a somewhat greater energy output. It is being evaluated at NOL as a new explosive of the booster type, as it is greatly superior to tetryl in thermal stability at high temperatures. A by-product was encountered in its preparation, whose identity is unknown.

NavOrd Report 2450
Detonation Velocities of Several New Explosives Measured by the Small Scale Technique, 19 May 1952, L. D. Hampton

Measurements of detonation velocities of new explosives, made during the period 1 July 1951 to 29 February 1952 by the small scale technique are reported. The explosives described in this report are ethylene di-4,4,4-trinitrobutyrate, methyldinitrotriazole, bis(trinitroethyl)urea, mixtures of bis(trinitroethyl)urea with waxes and with TNT, bis(trinitroethyl) fumarate, bis(trinitroethyl) succinate, bis(trinitroethyl)nitramine and heptanitropentane. The results indicate that ethylene di-4,4,4-trinitrobutyrate, which is a possible substitute for TNT, has a detonation velocity somewhat higher than that of TNT, and that bis(trinitroethyl)urea is quite similar to RDX in detonation velocity either alone or in its Comp A and Comp B analogues. Evaluation of the bis(trinitroethyl)urea Comp A analogue was reported in detail in NavOrd 2287.

NavOrd Report 2451
The Optimum Height of Burst for High Explosives, 21 July 1952, G. K. Hartmann, and P. Z. Kalavski

Peak pressure measurements, made at a reduced distance of 0.18 ft/lb$^{1/3}$ above a concrete reflecting slab, for various heights of burst are described. The measurements are in agreement with the

values predicted by the theory of regular reflection up to pressures as high as 15 psi. Height of burst curves are constructed based on the data below 15 psi. Comparison of these curves with other available high explosive data reveals agreement for all reduced heights [ft/(lb)$^{1/3}$] below 8, and disagreement for heights above 8 wherever pressures are below 8 psi. These curves indicate that by choice of the optimum height the ground area covered by a given pressure is increased.

It is pointed out, that the shape of the curves near optimum height may depend on the size of the gage used since pressures measured at or near the triple point are the result of averaging the three shock configurations over the gage area.

NavOrd Report 2455
Apparatus for Measurement of PVT Relationships of Gases at High Temperatures and Pressures: Effects of Changing the Initial Operating Conditions, 3 June 1952, R. S. Allgaier, Unclassified

This report is a supplement to NOLM 10526 which describes an adiabatic compressor for obtaining PVT data on gases at simultaneously high temperatures and pressures. The changes in the maximum pressure, maximum temperature, and minimum volume produced by different combinations of reservoir pressure and initial test gas pressure are tabulated, graphed, and discussed. Although a variety of peak conditions may be realized by the proper choice of initial conditions, the latter must be carefully controlled to avoid dangerously high maximum pressures and low minimum volumes. An additional calculation is included which corrects a column in the table of NOLM 10526 presenting data describing an idealized compressor cycle.

NavOrd Report 2460
Low Velocity Detonation of Certain Primary Explosives, 28 May 1952, R. H. F. Stresau, Unclassified

The nature of the damage sustained by tubes in which the explosives were confined indicated that both lead azide and mercury fulminate, when pressed to rather high densities, reacted in a very different manner than when loaded at slightly lower densities. It was found that this different type of reaction was induced by initiation within a limited range of vigor. Measurements of propagation velocity gave three ranges for mercury fulminate 4,000 to 5,000 meters per second, 1,400 to 1,700 meters per second and a few inches per second. Only the two upper ranges were observed for lead azide. More vigorous initiation resulted in a greater tendency toward reactions in the higher velocity ranges. Further observations of the intermediate, 1,400 to 1,700 meters per second, velocity range of mercury fulminate showed no difference between the velocities obtained with 0.1 and

0".15 diameter columns nor did the velocity vary when measured over 1, 2, and 3 inch column lengths. An attempt to induce a reaction of this type in 0".2 diameter columns resulted only in reactions which propagated at velocities in the high range of 4,000 to 5,000 meters per second. Experiments with various confining media seemed to show some effect of confinement, but the results were too scattered to be statistically significant. Several possible mechanisms of the reaction are discussed.

NavOrd Report 2462
The Response of Air-Backed Plates to High-Amplitude Underwater Shock Waves, 1 May 1952, H. G. Snay and E. A. Christian, Unclassified

The response of a free plate to a plane high-amplitude underwater shock wave has been calculated by use of the method of characteristics. The method employed is described in some detail. The pressure, velocity and energy distribution at and near the plate are shown for incident waves of zero to 40 kilobars peak pressure.

NavOrd Report 2468
Primary Explosives Research, 3 June 1952, F. Taylor, Jr.

The following metal salts of 5-nitrotetrazole were prepared and examined as possible new primary explosives; cupric, ferric, ferrous, lead, mercuric, mercurous, silver, tin and zinc. The methyl derivative of 5-nitrotetrazole and 5-trinitroethylaminotetrazole were also prepared and studied as possible new primary explosives. All but the silver and mercurous salts and the methyl and 5-trinitroethylamino derivatives were rejected because of excessive water solubility. All of these tetrazole derivatives except 5-trinitroethylaminotetrazole have good thermal stability and posses impact sensitivities in a desirable range. The silver salt appeared rather promising as it was more sensitive to stab initiation than lead azide or basic lead styphnate and produced a higher output. The methyl derivative possessed excellent thermal stability and the unique property of being a castable primary explosive. Further tests are being made on these compounds and the results will be reported elsewhere.

NavOrd Report 2480
A Redetermination of the Molar Extinction Coefficients of Aqueous Nitroform Ion, 16 May 1952, A. O. Long

This report presents new measurements of the ultraviolet absorption spectrum of nitroform ion in aqueous solution.

NavOrd Report 2484
A Simplified Procedure for Field Identification of Some Military High Explosives, 3 July 1952, J. M. Rosen, and V. H. Galloway

A simplified procedure for the field identification of fourteen military high explosives has been devised. At present this procedure includes the following: amatol, ammonium nitrate, Composition A, Composition B, Composition C, Explosive "D", HBX, HND, PETN, picric acid, RDX, tetryl, TNT and torpex. Based on solubilities and color reactions only five reagents are required: carbon tetrachloride, acetone, 2% ammonium hydroxide, 2% potassium hydroxide and 1% diphenylamine along with a set of test tubes and a sample scoop.

NavOrd Report 2487
The Effect of Soil Barriers on Shaped-Charge Penetrations, 27 June 1952, W. T. August, and A. D. Solem

Jet penetration into mild steel targets with loosely packed, sandy clay soil barriers between the shaped charges and the targets has been investigated. It has been found that penetration into the steel decreased rapidly with barrier thickness for the first few inches. The rate of decrease was found to diminish as the barrier was made thicker. Penetration with change of standoff occurred in a regular fashion, but was of secondary importance.

NavOrd Report 2494
A Small Scale Gap Sensitivity Test, 2 July 1952, W. E. Dimmock, Jr.

This report describes a method whereby the sensitivity of explosives to initiation by other explosive may be evaluated when only a small sample of the explosive is available. Cylindrical brass containers 1" in diameter and 1/4" long with 0.100" diameter centrally drilled holes were used to contain the explosive to be tested. The use of such small columns makes it possible to obtain statistically valuable data from small amounts of explosive. The depth of a dent in a steel block placed at the back of the explosive column was used as a criterion to determine whether the shot was a fire or misfire. The order of decreasing sensitivity of the five explosives tested was found to be RDX, tetryl, Comp B, TNT and Comp A. This is in agreement with results of similar larger scale experiments.

NavOrd Report 2496
Primary Explosives Research V. Preliminary Investigations on the Purification and Control of the Crystal Growth of Silver 5-Nitrotetrazole, 23 June 1952, J. P. Wintermoyer

A preliminary investigation of a method of purifying and controlling the crystal habit of silver 5-nitrotetrazole to produce a product having

satisfactory physical properties is described. Essentially the method consists of precipitation of the salt from an aqueous ammonical solution by means of nitric acid. Crystal growth control agents are beneficial. Further work on this method will await further evaluation of the compound by the Engineering Department of the Naval Ordnance Laboratory.

NavOrd Report 2497
Preparation and Properties of 2,2-Dinitropropanol Esters, 3 July 1952, M. E. Hill

2,2-Dinitropropanol esters of 4,4,4-trinitrobutyric acid (I), fumaric acid (II) and N-trinitroethylnitraminoacetic acid (III) have been prepared by reaction with the acid chloride in the presence of anhydrous aluminum chloride.

I melts at 94.4°, essentially at the same temperature as the corresponding trinitroethyl ester. TNETB, and apparently forms mixed crystals with it. I is considerably less sensitive than TNETB and has a detonation velocity about 600 meters per second faster than TNT. It may be of interest as a castable explosive.

II melts at 86°, has a 50% explosion height above 320 cm and is thus very much less sensitive than the corresponding trinitroethanol ester. As it appears to be slightly waxy, it may be of interest.

IV melted at 144° with gas evolution and was quite sensitive.

A comparison of several compounds containing the dinitroethyl group in place of the trinitromethyl shows that the former have equal or better stability, lowered sensitivity and crystal density, and of course, lower oxygen content.

NavOrd Report 2498
The Preparation of 2,2,2-Trinitroethyl 4,4-Dinitropentanoate, 3 July 1952, D. W. Jensen

2,2,2-Trinitroethyl 4,4-dinitropentanoate has been made by the addition of 1,1-dinitroethane to methyl acrylate, hydrolysis of the methyl ester and esterification of the resulting acid with trinitroethanol. The compound is a castable high explosive, m.p. 92.5°C; crystal density 1.60; impact sensitivity 70 cm; hot bar ignition temperature 297°C; vacuum stability 1.1 cc of gas/g/48 hours at 100°C.

NavOrd Report 2553
Underwater Performance of an HBX and Three Explosives Containing Ammonium Perchlorate, 1 July 1952, J. A. Goertner, C. R. Niffenegger, and J. P. Slifko

Shock wave pressure-time histories and bubble periods were measured from 50-lb charges. The charges which contained ammonium perchlorate and aluminum, with either or both RDX and TNT, showed considerably more power than HBX-1. An HBX with 47.5% aluminum gave less shock wave energy but considerably more bubble energy than HBX-1. The results are tabulated and shown graphically.

NavOrd Report 2575
Underwater Explosion Parameters for 50-50 Pentolite, 15 July 1952, J. A. Goertner and E. Swift, Jr.

Data on the underwater performance of 50-50 pentolite have been compiled. Tables and graphs of shock wave peak pressure, momentum and energy, and of bubble periods and radii are given. Some unreported values are included.

NavOrd Report 2579
The Sensitivity of Explosives, 7 August 1952, Russell McGill, Restricted

A translation of a lecture on "The Sensitivity of Explosives", by Masayoshi Niimi in Japanese is given. An abstract of this lecture which appeared in Chemical Abstracts, 33, 4423 (1939) was taken verbatim from the Japanese Journal of Engineering, 16, 62 (1938). The author claims to have proved the accuracy of his calculated theoretical formula for sensitivity of explosives. Therefore, it seemed worthwhile to obtain the text of the complete lecture, to have it translated and to make a complete English text of the lecture available to those concerned with sensitivity of explosives.

NavOrd Report 2584
The Effect of the Air Blast From HBX-1 Charges Cased in Cellulose Acetate and Cellulose Nitrate Cylinders, 29 December 1952, E. M. Fisher

Two nitrocellulose/resin cased charges, two cellulose acetate/resin cased charges, and two bare HBX-1 charges were fired in free air to compare their air blast effectiveness. The results are tabulated below, based on equal weights of high explosive, HBX-1.

	Nitrocellulose/resin cased charge	Cellulose acetate/resin cased charge
Peak pressure relative to bare HBX-1	1.20	1.21
Positive impulse relative to bare HBX-1	1.15	1.24

From these results it appears that the inflammable nitrocellulose case was not contributing to the air blast in any different way than the relatively inert cellulose acetate case. The substantial increase in blast performance appears in the opinion of the author, to be due to the so-called "cover effect".

The cellulose acetate case was calculated to equal HBX-1 in blast effectiveness whereas the nitrocellulose cases were only about 90 per cent as effective as HBX-1. This result only holds for the conditions in these particular experiments.

NavOrd Report 2589
Booster Sensitivity of Ammonium Perchlorate Explosives, 19 August 1952, C. C. Lovenberg

This is a progress report of the booster sensitivity of ammonium perchlorate explosives, part of the development of a high explosive containing ammonium perchlorate, aluminum and TNT or RDX for underwater use. Explosive compositions containing ammonium perchlorate, TNT and aluminum are referred to as DY. Those in which RDX is used in place of TNT are known as DX. Mixtures containing both RDX and TNT as the high explosive ingredient are called DYX explosives.

Booster sensitivities of various bulk density compositions are reported. Booster tests for nineteen DY-1 (55.5% ammonium perchlorate/ 18.3% TNT/26.2% aluminum) have been determined. Some factors which influence the sensitivity of pressed DY-1 are discussed.

Many cast perchlorate compositions are relatively insensitive to booster impact. Miscellaneous sensitivities of cast compositions are summarized. Sensitization of cast mixes is discussed briefly.

NavOrd Report 2596
Modification of the Autoclave Engineers Compressor, 25 August 1952, D. Price, and J. B. Lewis, Unclassified

The design of several parts of the compressor constructed by Autoclave Engineers has been changed and new parts constructed at NOL. These parts which are described in this report include an end plug cover, a side window assembly, and a new piston face. Their installation reduces dead space to 16 - 30% of the volume of the gas at maximum compression, V_r, and thus operation of this compressor at pressures for which it was designed can now be attempted. Measurements reported here suggest two other simple modifications to reduce the dead space to 6 - 20% V_r.

Successful replacement of neoprene with aluminum gaskets and correction of the piston release mechanism are also reported.

NavOrd Report 2600
Catalysis of Trinitroethanol Esterification, 30 June 1952, M. E. Hill

A study has been made of the relative reactivity of several metal halides in catalyzing the reaction of 2,2,2-trinitroethanol with acid chlorides. The following metal halides, listed in decreasing order of activity, were found to be effective: aluminum chloride, titanium tetrachloride, antimony pentachloride, stannic chloride, boron trifluoride, ferric chloride, zinc chloride, and mercuric chloride. A comparison of the effect of varying amounts of aluminum chloride upon the reaction velocity showed that molecular proportions were unnecessary for a rapid reaction.

Trinitroethanol with aluminum chloride gave a somewhat unstable compound, trinitroethyl dichloroaluminate, which readily reacted with succinyl and benzoyl chlorides to give the corresponding esters in good yield. It may be an intermediate in metal halide catalyzed esterifications.

Nitrobenzene was found to be an excellent solvent medium for these esterifications.

Trinitroethyl 3,5-dinitrobenzoate has been prepared by this method. It is a thermally stable compound having an impact sensitivity approximating that of Composition B.

NavOrd Report 2608
Kinetic Study of the Thermal Decomposition of Some Organic Nitrates. II. n-Propyl Nitrate and tert-Butyl Nitrate, 22 December 1952, J. B. Levy, and F. J. Adrian, Unclassified

The thermal decomposition of n-propyl nitrate in the vapor phase has been studied thoroughly at 181°C and pressures of about 35 mm Hg. Preliminary studies have been carried out on tert-butyl nitrate at the same temperature and pressures. An analytical technique using the infrared spectrometer and the ultraviolet spectrophotometer has made it possible to follow the disappearance of the reactant and the appearance of the products directly.

It has been found that n-propyl nitrite and nitroethane are important products of the n-propyl nitrate decomposition, while tert-butyl nitrite is formed from the decomposition of tert-butyl nitrate. The effect of various competitive reagents and reaction products on the n-propyl nitrate decomposition has been studied.

The mechanism of nitrate ester decomposition is examined in the light of the results of this work.

NavOrd Report 2611
The Rates of Detonation of Several Pure and Mixed Explosives, 22 September 1952, N. L. Coleburn, and T. P. Liddiard

The detonation velocities of twenty-three pure and mixed (including aluminized) explosives have been determined with the rotating mirror streak camera. Detonation velocities at various loading densities for thirteen explosives and explosive mixtures have been tabulated graphically. The line drawn through the points is believed to be characteristic of the maximum hydrodynamic rate. Comparative detonation rates vs. density and pressures have been calculated on the basis of hydrodynamic theory, the Kistiakowsky-Wilson equation of state and available heat of formation data. In these calculations for aluminized explosives, the assumption was made that $Al_2O(c)$ is one of the products.

NavOrd Report 2614
Evaluation of 2,2,2-Trinitroethyl 4,4,4-Trinitrobutyrate as a Constituent of Castable Explosives, 30 September 1952, L. D. Hampton, and G. Svadeba

2,2,2-Trinitroethyl 4,4,4-trinitrobutyrate, designated TNETB, has been produced in sufficient quantity to permit fairly extensive evaluation as a military explosive. The preliminary evaluation of TNETB as a substitute for TNT in explosives such as cyclotol and octol was done by the Explosives Properties Division.

TNETB, in common with a number of other explosives, including RDX, is too sensitive to mechanical shock to be acceptable as a military explosive. Therefore, a desensitizer for TNETB and one which would yield with TNETB and RDX or HMX, an explosive with sensitivity comparable with that of Comp A was sought. These objectives have been realized. The results are reported.

Measurements of detonation velocities observed with small, highly confined columns of RDX/TNETB/wax and HMX/TNETB/wax for six different varieties of wax are reported. The percentages of the components were 60/34/6 in each case. Crown Wax 23 and Crown Wax 36 gave the highest velocities at low loading pressures. At the maximum loading pressure mixtures containing Crown Wax 700 gave a higher velocity than any other. This maximum value was near 8,400 m/sec for RDX/TNETB/wax and 8,600 m/sec for HMX/TNETB/wax.

NavOrd Report 2625
The Design and Construction of a Precise Projection Type Micro-Comparator, 2 October 1952, H. P. Feldman, Unclassified

This report describes the design, construction and use of a new projection type micro-comparator. This comparator, designed for

maximum operator comfort and a minimum of effort and eyestrain, is capable of reading distances on film accurately to within 0.001". Measurements of distances up to 15 inches in the X direction and 9 inches in the Y direction can be made. Direct reading of distances, (no verniers and no subtraction), are made by the use of mechanical counters able to reset to zero when the operator desires.

NavOrd Report 2630
Detonation Velocities of Certain Selected Binary Explosive Mixtures, 1 October 1952, L. D. Hampton

The results of detonation velocity measurements made by the small scale technique on four classes of mixtures are reported. In the first group, the explosives 1,7-diamyloxy-2,4,6-trinitro-2,4,6-triazaheptane, DATT, and 1,7-dimethoxy-2,4,6-trinitro-2,4,6-triazaheptane, DMTT, were used as desensitizers for RDX and HMX. In the second group, sugar and other organic substances were used as diluents to test the theory that a higher detonation velocity could be obtained by the use of a high density desensitizer whose density was high because of a greater number of oxygen atoms in its molecule. In the third group, the additive was succinonitrile, and in the fourth, it was a metallic compound. In these cases either an increased heat of reaction might be anticipated or the products of the reaction could be expected to have a much larger increase in volume than usual. However, an increased detonation velocity was not observed in these cases.

NavOrd Report 2644
Initiation Times of Various Primary Explosives, 14 October 1952, W. K. Meyer, and R. H. F. Stresau

The time intervals between firing pulses and external evidence of detonation of a series of detonators have been measured. The detonators were identical except various primary explosives had been used as flash charges. Firing pulses were discharges of 0.0047, 0.05, and 0.5 microfarad condensers all charged to 450 volts. With the 0.5 microfarad condenser the times measured were about one and a quarter microseconds for lead and silver azide and around ten microseconds for mercury fulminate, lead styphnate and diazodinitrophenol. The times obtained with the 0.05 microfarad condenser were, in general, slightly longer, while those obtained with the smallest condenser were two to four times as long and quite erratic, individuals running to several hundred microseconds. All of the flash charge explosives were ground in a ball mill and an inconclusive attempt was made to determine the effect of milling time. A few experiments were also made with varied quantities of flash charge explosive.

NavOrd Report 2647
Impact Sensitivity of Primary Explosives, 1 November 1952, G. Svadeba

The relative sensitivities of various primary explosives have been determined using 0.5, 1.0, and 2.5 kg weights. The sensitivities of several high explosives are included for comparison. The Bruceton Explosives Research Laboratory drop-weight impact machine was used with type 12 tools to determine the relative sensitivities. This relative order of sensitivities was the same within the realm of experimental error, regardless of the weight used. The use of the lighter weights for differentiating the sensitivities of primary explosives is indicated. Smaller differences in sensitivities are apparent and the method is more discriminating because the 50% heights are spread over a longer scale.

NavOrd Report 2673
Preliminary Examination of High Pressure P-V-T Data up to 1000°C, 1 December 1952, D. Price, Unclassified

An examination of Harvard P-v-t (pressure-volume-temperature) data for water to 1000°C and 2500 bars showed that for specific volumes of 5 cc/g and less, $(\Delta P/\Delta T)_v$ is constant to within the limits of experimental error at the higher temperature end of the isochore. The region of such constancy varied for each isochore; its lower limits of pressure and temperature increased with increasing specific volume.

Up to 400 bars, the Harvard data appear to be less reliable than the International Steam Table data which have a precision of 1/1000. At very low specific volumes (high pressures), the precision was not sufficient to demonstrate the existence or absence of a density effect on the $(\Delta P/\Delta T)_v$ vs t curve near the liquid-vapor equilibrium region. Such an effect would be expected if a maximum in the heat capacity, c_v, occurs at the critical density.

Harvard P-v-t data for CO_2 to 1000° and 1400 bars were obtained in the same manner the water study was made, but with improved apparatus and procedures. Comparison of the carbon dioxide data with those from the Van der Waals Laboratory indicated an agreement to 0.1% in Pv for $P > 400$ and $t \geq 100$°C. This is also thought to be the experimental precision of the Harvard work. As in the case of water the lower pressure -- lower temperature measurements seemed less accurate than those in the higher ranges.

It is planned to use the carbon dioxide data and more precisely determined water data for the computation of thermodynamic functions in the high temperature regions that have not been previously explored.

NavOrd Report 2681
Peripheral Initiation of Shaped Charges II. Penetration Patterns for Different Shaped Charge Parameters and Initiator Barriers Using Steel Liners, 1 October 1952, W. T. August and A. D. Solem

Penetrations from peripherally initiated 1 5/8 inch cylindrical shaped charges have been investigated for change of charge height, standoff, liner apex angle, and liner wall thickness. The effects which modification of the peripheral initiator (changes in barrier material or thickness) have on penetrations were also investigated. The variation of penetrations for change of charge height was found to be the same as reported earlier. The behavior of penetrations with change of standoff, apex angle, and wall thickness are similar to those obtained for this type charge when point initiated. Lead oxide appears to be the best barrier although several substitutes are almost as effective. Any thickness of lead oxide greater than 0.2 inches has been found to produce peripheral initiation.

NavOrd Report 2696
The Decomposition of Diethyl Peroxide in the Presence of Nitric Oxide and Ethyl Nitrite, 30 December 1952, J. B. Levy, Unclassified

The reaction between ethoxyl radicals and nitric oxide at 181°C has been studied using the decomposition of diethyl peroxide as the source of ethoxyl radicals. It has been found that ethyl nitrite is formed. The effect of ethoxyl radicals on the decomposition of ethyl nitrite has been examined at 181°C. The mechanisms of the thermal decomposition of nitrite esters and nitrate esters are discussed in terms of the results obtained.

NavOrd Report 2698
Relaxation Oscillations in Voltage-Regulator Tubes, 5 December 1952, P. L. Edwards, Unclassified

Gas-filled voltage-regulator tubes are subject to relaxation oscillations when operated in parallel with a condenser. These oscillations have been investigated and a qualitative description of their mechanism is presented. It was found that the voltage across the tube as a function of current has a minimum, and that if the current through the tube is greater than that at the voltage minimum, then relaxation oscillations do not occur. It was also found that a 100 ohm resistance in series with a VR105 tube reduces the tube current required to prevent oscillations. Sinusoidal oscillations were observed. The equivalent inductance of a VR105 was observed to increase with decreasing tube current and decreasing frequency.

ABSTRACTS OF TECHNICAL NOTES

TN-821
Evaluation of Dinitroneopentane as an Explosive Wax, 14 February 1952, D. W. Jensen

Dinitroneopentane, (2,2-dimethyl-1,3-dinitropropane), was prepared for evaluation as an explosive wax. Its stability and sensitivity proved to be satisfactory, but the compound is too volatile at ordinary temperatures to be of use. For this reason work on the compound as a practical explosive component was discontinued.

2,2-Dimethyl-1,1,3-trinitropropane was prepared by the addition of another nitro group to the above compound. It is a waxy material. Because it is also too volatile, and expensive to prepare, and difficult to purify it is of no interest.

TN-1227
Summary of Experimental Data on Underwater Performance of HBX Type Explosives, 10 March 1952, E. A. Christian

Tables and graphs of results of underwater comparisons of HBX type explosives are given. The explosives considered include those compositions with 0-45% aluminum in a 42/40 RDX/TNT matrix. Shock wave pressure, momentum and energy, bubble periods and bubble pulse pressure, momentum and energy are presented.

TN-1250
Air Blast Peak Pressures Along the Water Surface from Shallow Underwater Explosions, 15 March 1952, C. R. Niffenegger

Air blast peak pressures have been measured along the water surface from explosions at the surface and from shallow underwater explosions. The data are presented graphically in preliminary form.

TN-1322
Booster Tests with Simulated Mk 43 Mod 1 Torpedo Warheads, 7 May 1952, C. R. Niffenegger

Twelve simulated Mk 43 Mod 1 torpedo warheads loaded with HBX-3 were fired underwater. The results indicate that the proposed 110 gram tetryl booster is adequate for high order detonation.

TN-1331
Explosives Containing Titanium, 22 April 1952, H. G. Snay

It is shown by an approximate calculation that titanium-RDX mixtures could yield almost as much explosion energy as aluminum-RDX mixtures, on an equal volume basis. There is a possibility that the titanium mixture might have better shock wave properties.

TNT-1332
Explosives Containing Fluorine or Chlorine, 22 April 1952, H. G. Snay, and J. H. Rosenbaum

Replacing the hydrogen in high explosive compounds with chlorine, or more particularly fluorine, might possibly give great increases in explosive performance, either with the unmixed compound or with aluminized mixtures.

TN-1347
Some Improvements in the Method of Calibration of Piezoelectric Pressure Gages, 8 May 1952, R. W. Astheimer, Unclassified

A new microcoulometer of increased stability and sensitivity has been designed and constructed. A possible consistent error due to dielectric absorption in standard capacitors was analyzed and corrected. The pressure release system has been improved and another system built to produce a rising pressure step. It was found that gage calibrations agree well both on rising and falling pressure steps.

TN-1352
Small Charge Tests on Some Low Impedance Tellurium Pressure Gages, 8 May 1952, R. W. Astheimer, Unclassified

Five 1/8 in. tellurium pressure gages were tested by using them to obtain underwater shock wave records from 1 gram detonators and comparing these with records from a 1/4 inch tourmaline gage used as a standard. The tellurium gage records were quite distorted and not reproducible. The effect of the plastic coating was investigated and it was found that this caused some but not all of the erratic behavior.

TN-1380
Potential Damage to Low Flying Aircraft from Exploding 2000 Pound Mines, 26 May 1952, A. D. Solem, and N. Shapiro

The possibilities of damage to mine laying aircraft and following aircraft from prematurely exploding mines has been investigated from the standpoint of both the air blast and fragmentation patterns surrounding the exploding mine. This investigation led to the

following opinions:

(a) The possibility of damage from fragmentation to the launching aircraft in normal mine drop is very small for all heights above 240 feet. In abnormal drop there may be a slight possibility of damage at low altitudes. This diminishes to zero for altitudes of 275 to 300 feet.

(b) The possibility of damage from fragmentation to following aircraft depends critically upon whether or not the following aircraft is in the neighborhood of the exploding mine at time of explosion. The possibility of damage exists if the aircraft is less than 2000 feet from the exploding mine. Expectation of serious damage could occur at distances 1000 to 1200 feet or less.

(c) The possibility of damage from air blast to the launching aircraft in normal mine drop is negligible for any height above 240 feet. The possibility of damage from air blast to a following aircraft is small if the aircraft is further than 450 to 500 feet from the explosion.

TN-1395
Requirement for New Materials in Explosive Components for Fuzes, 4 June 1952, J. E. Ablard

New materials, explosive and non-explosive, are sought in order to impart improved properties to fuzes. Worthwhile improvement include greater reliability at time of manufacture and continuing reliable life. Means of producing more reliable fuze components and of recognizing improvement are discussed. Specifically the requirements for new materials and tests designed to evaluate new primary explosives as fuze components are described.

TN-1409
Evaluation of Bullet Resistant Glass for Use in Laboratory Safety Shield, 9 June 1952, F. Taylor, Jr., Unclassified

Experiments designed to determine the degree of protection afforded by laboratory safety shields are described. These experiments support the following conclusions: (a) the safety shield constructed as shown with inch thick bullet resistant glass affords adequate protection for all reasonable laboratory experiments. An undamaged shield will probably withstand a high order detonation of 60 g of TNT, where the distance is eight inches or more. It is seldom that one experiences a high order detonation of this type in the laboratory. "Low-order" explosions due to sudden gas pressure or "fume-off" are the usual result of uncontrolled decomposition of high explosive undergoing a reaction, (b) the half inch thick bullet resistant

glass shield would probably prove adequate for small scale experiments that are usually carried out in the laboratory, where the shield is eight inches away and the entire reactants do not exceed an amount equivalent to 20 g of TNT.

Report of this work was published in Chemical and Engineering News, November 3, 1952, page 4668.

TN-1495
A Preliminary Experimental Evaluation of the Electrokinetic Gage as a Pressure and Impulse Measuring Device for Air Blast, 17 July 1952, N. Maropis, Unclassified

An electrokinetic gage (EK-G) was tested under explosive shock varying in pressure from 5 to 94 psi. It showed a discontinuous pressure rise, and compared favorably with a tourmaline gage of known dynamic sensitivity in all but the impulse reading. The impulse reading was consistently high by approximately 2 to 12 per cent as compared to that obtained from the tourmaline gage. The sensitivity of the EK-Gage No. (3-4) was found to be 0.170 volts/psi. The gage was also found to be linear.

TN-1501
Free Air and Ground Level Pressure Measurements on Operation Tumbler Preliminary Reports on, 29 July 1952, C. J. Aronson, J. F. Moulton, Jr., J. Petes, and E. J. Culling

A bibliography of preliminary reports on this operation.

TN-1511
Potential Damage to Launching Aircraft from Exploding 2000 Pound Mine After Free Fall Launching, 21 July 1952, A. D. Solem

The investigation reported, a continuation of that reported in TN-1380, has led to the following opinions. The launching aircraft would not be damaged by premature detonation of a free falling 2000 pound mine launched from any altitude greater than 400 to 425 feet. The possibility of damage exists for lower launching altitudes, and the probability of damage would increase rapidly as the launching altitude is decreased below 400 feet. Damaging fragmentation hits would be quite likely to occur at any launching altitude less than say 350 feet. The aircraft would surely be seriously crippled or destroyed from either fragment or air blast damage for launching altitudes less than 300 feet.

TN-1617
A Delayed Pulse Generator, 18 September 1952, R. L. Varwig, Unclassified

A delayed pulse generator has been designed and constructed to serve primarily as a calibrating device for the ratio delay timer used in connection with shock tube photography. The generator is basically a one-shot multivibrator based on the Eccles-Jordan flip-flop principle. The circuit of the generator and a description of its operation is included.

TN-1636
The Heat of Combustion of Some High Explosives, 29 September 1952, D. Sickman

Heats of combustion of explosives determined by the Thermochemistry Section of the National Bureau of Standards are given. The heat of combustion, $-\Delta H$, is the heat evolved on combustion at constant pressure with all the reactants and products in their thermodynamic standard states at 25°C, and thus refers to the reaction:

$$C_aH_bO_cN_d + (a + b/4 - c/2)\ O_2\ (\text{gas, 1 atm})$$

$$= aCO_2\ (\text{gas, 1 atm}) + b/2\ H_2O\ (\text{liquid}) + d/2\ N_2\ (\text{gas, 1 atm})$$

The heat of formation is calculated from the heat of combustion by use of the values 68.317 ± 0.010 kcal/mole and 94.052 ± 0.011 kcal/mole for the heats of formation of liquid water and carbon dioxide gas respectively. This heat of formation ΔH is then the heat absorbed in the following reaction at 25°C and a constant pressure of one atmosphere, with all the reactants and products in their thermodynamic standard states:

$$aC(\text{solid graphite}) + b/2\ H_2(\text{gas}) + c/2\ O_2\ (\text{gas})$$

$$+ d/2\ N_2(\text{gas}) = C_aH_bO_cN_d$$

Note that ΔH is positive when heat is absorbed in the reaction as written. The unit used is the kilocalorie, taken as 4.1840 absolute joules.

The compounds burned were, with the exception of nitroform, of exceptional purity. Most of them were prepared or purified at NOL.

The results should be considered tentative until a formal report is issued by the Bureau of Standards.

Compound	$-\Delta H$ kcal/mole /a	$-\Delta H_f$ kcal/mole /b
Nitromethane (l)	169.49 ± 0.14	-27.04
Nitroethane (l)	324.57 ± 0.25	-34.33
1-Nitropropane (l)	480.91 ± 0.19	-40.36
2-Nitropropane (l)	478.17 ± 0.19	-43.10
1,1-Dinitroethane (l)	290.07 ± 0.25	-34.67
1,1-Dinitropropane (l)	447.07 ± 0.10	-40.04
2,2-Dinitropropane (s)	441.39 ± 0.12	-45.71
Nitroform (l)	119.0 ± 0.5	- 9.2
1,1,1-Trinitroethane (s)	263.05 ± 0.23	-27.53
1,1,1-Trinitropropane (l)	424.89 ± 0.22	-28.06
Tetranitromethane (l)	107.1 ± 0.8	+13.0
4-Methyl-3,5-dinitro-triazole (s)	413.98 ± 0.27	+29.35
RDX	501.82 ± 0.25	+14.71
HMX	667.41 ± 0.20	+17.93

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/a $-\Delta H$ is the heat evolved in the combustion at 25° with the water liquid.

/b ΔH is the heat absorbed in the formation of the compound from the elements.

TN-1649
Frequency Response and Accuracy Consideration for Air Blast Pressure-Time Measuring Systems, 7 October 1952, C.J. Aronson

An investigation into the approximate relations between charge weight, accuracy requirements for air blast pressure-time measurements, and the frequency response of the measurement system indicates, for example, that a piezo-electric gage system can measure the pressure time curves in the medium pressure ranges from 8-pound charges to about 5 per cent precision. It also indicates that similar precision can be maintained when 250-pound charges are used instead of 10,000 pound charges if the high-frequency response of the measurement system is increased from 1120 cps to 3840 cps.

TN-1779
Discussion of the Validity of the Shock Velocity Method of Air Blast Gage Calibration Near a Reflecting Surface, 8 December 1952, E. M. Fisher

It has been called to the attention of the author that the velocity method of calibration of air blast gages near a reflecting surface might be in error. Investigation of the calibration of two gages calibrated both in the free air region and in the far Mach region near a reflecting surface shows no significant differences in the calibrations. It is pointed out that this evidence is not considered final and that a systematic investigation of the variables involved is needed to answer this problem satisfactorily.

TN-1784
Preliminary Examination of the Eutectic Composition Between MNO (N,N'-Dinitrodimethyloxamide) and PETN as a Possible Castable Explosive, 8 December 1952, D. W. Jensen

N,N'-Dinitrodimethyloxamide, known as MNO, has been prepared and its eutectic composition with PETN examined. This eutectic melted at 104°C and consisted of 70% by weight of PETN to 30% of MNO. However, the thermal stability of the melted eutectic was insufficient for consideration as a castable explosive, and its impact sensitivity indicated that desensitization would be required to make the mixture safe to handle.

ABSTRACT OF NOLR

NOLR 1169
Base Surge Analysis - HE Tests, Operation Jangle Project 1(9)-4, G. A. Young, May 1952

Base surge and related surface phenomena were measured on photographic records of the 1951 underground explosion tests in soils at Dugway, Utah and the Operation Jangle HE tests. Data

concerning ground-rise, smoke crown, column, jet, and base surge behavior are presented.

A base surge is produced by TNT explosions at scaled depths (λ_c) ranging from zero to 3.07 ft/lb$^{1/3}$, the greatest depth in these programs, but is small and tenuous at scaled depths less than 0.2 ft/lb$^{1/3}$. The surge has the highest velocity and greatest extent at a λ_c of about 1.0 ft/lb$^{1/3}$.

Base surges are formed in the three Dugway soil types, but explosions in dry sand produce the largest, and wet clay the smallest surges, with explosions in dry clay intermediate. Thus, it appears that soils with low seismic velocities have the physical characteristics best suited for the formation of a base surge.

Froude scaling is adequate for reducing the surge radial growth data at scaled depths from about 0.2 to 2.0 ft/lb$^{1/3}$. At a λ_c of 0.508 ft/lb$^{1/3}$, comparison with liquid model results indicates a 1.9 ratio of column density to atmospheric density. Similarities between the base surges formed by underwater and underground explosions are noted.

Areas of dust deposit and crater dimensions also indicate that a scaled depth of 1.0 ft/lb$^{1/3}$ is near the optimum for base surge formation.

ABSTRACTS OF PAPERS PRESENTED AT TECHNICAL SOCIETY MEETINGS

"Propagation of Explosive Produced Air Shocks", American Physical Society, St. Louis, Missouri, 28-29 November 1952, J. Savitt

It has been previously reported* that the velocities of ionized air shocks produced by the detonation of highly confined solid explosives depend upon the distance from the explosive air interface, the composition of the explosive, its weight, its geometry and to some extent for a particular explosive upon its loading density and particle size. These small scale, one dimensional ionized air shock propagation experiments near detonating explosives have been extended to include measurements made in heavy walled tubes varying in internal diameter from 0.100 to 0.300 inches. The velocities of one dimensional air shocks produced by detonating highly confined TNT and RDX were measured at several distances from the explosive air interface. These

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*J. Savitt and R. H. Stresau, Phys. Rev. 85, 732 (A), (1952)

velocities were found to depend upon the diameter of the explosive as well as upon the diameter of the shock tube. It was found that, in general, for a fixed shock tube diameter that the air shock velocity increased with increasing explosive diameter, while for a fixed explosive diameter it was observed that the air shock velocity increased with decreasing shock tube diameter.

"Low Velocity Detonation of Certain Primary Explosives," American Physical Society, Washington, D.C., 1-3 May 1952, R. Stresau (Introduced by J. Savitt)

Under conditions of very high loading density and high radial confinement, and when marginally initiated, lead azide and mercury fulminate were found to react in an unusual manner. The propagation rate of the reaction was found to be between 1400 and 1700 meters per second as contrasted with a detonation velocity of over 5000 meters per second for the same materials at the same loading densities when more vigorously initiated. The interior of a hole through which such a reaction has passed is smooth and lustrous while one through which a normal detonation has passed is black and riddled with longitudinal cracks. Experiments with various confining media and column diameters show that these have little, if any, effect upon the propagation velocity but make adjustments of other conditions necessary in order to cause this type of reaction. Possible mechanisms of this type of reaction are discussed.

"Recent Air Shock Velocity Measurements Near Detonating Explosives," American Physical Society, 1-3 May 1952, J. Savitt, and R. Stresau

Previously reported small scale measurements* of ionized air shock velocities near detonating explosives have been extended to include measurements made with large numbers of different explosive systems. By confining the explosives and the air shocks in heavy walled cylindrical metal tubes, one dimensional propagation was approximated.

By assuming a linear relationship between the velocity of the explosive particles in the detonation and the mass of explosive between the detonation front and these particles, a simple relationship between the air shock velocity V, and the distance to the original explosive air-interface Y, is suggested by applying the principle of momentum conservation. This relationship, however, is found to be only in fair agreement with the observations.

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* R. H. Stresau, J. Savitt, American Physical Society Meeting, Chicago, Ill. October 1951

"Spalling Produced by Detonation of Explosives in Very Heavy Walled Metal Tubes", American Physical Society, 1952, Annual Meeting, New York, J. Savitt and L. E. Starr

In experiments with small, highly confined explosives, it was noted that under some conditions a conical slug of metal was torn from the free end of the metal container. After some speculation, this phenomenon was explained in terms of the convergence of tension waves which had been reflected from free surface. Experiments, in which explosives were used and the geometry of the containers were varied, confirm the explanation.

"Kinetics of Decomposition of Nitrate Esters. I. Ethyl Nitrate", Eighth Annual Joint Army-Navy Air Force Solid Propellant Meeting, Huntsville, Alabama, 4-6 June 1952, Joseph B. Levy, Restricted

The thermal decomposition of ethyl nitrate in the vapor phase has been studied at 160 - 201°C and pressures below 200 mm Hg. An analytical technique has been developed using the infrared spectrometer and the ultraviolet spectrophotometer which has made it possible to follow the disappearance of ethyl nitrate directly.

It has been found that ethyl nitrite is an important reaction intermediate. The formation and disappearance of ethyl nitrite and of nitrogen dioxide over the course of the reaction have been followed using the new technique.

The mechanism of nitrate ester decomposition is examined in the light of the results found in this work.

"A High-Speed High-Pressure Gage", Seventh National Instrument Conference, Cleveland, Ohio, September 9-10, 1952, P. L. Edwards (This conference was sponsored by the American Society of Mechanical Engineers)

The design and tests of a pressure gage for the measurement of high-speed transient pressures up to 100,000 psi is described. This gage was designed for use with the Naval Ordnance Laboratory adiabatic compressor.

The pressure gage consists of a thin x-cut quartz crystal cemented to a steel plate. The pressure bends the plate and stretches the crystal, producing an electrical signal proportional to the pressure. The frequency limitations are determined by the natural modes of vibration of the steel housing.

The gage response was tested by both impulse and step input signals. The natural frequency is about 80,000 cps with a damping about 2% of critical. These tests show that the gage response can

be approximately represented by a resistance-inductance-capacitance circuit. An analysis on this basis of the distortion by the gage of the expected pressure pulse indicates a maximum error in pressure measurement of 6%. If necessary a corrective circuit may be used to reduce this to about 1.5%.

The gage has been calibrated up to 50,000 psi. There is some question as to whether or not the crystal will fracture before 100,000 psi, the maximum desired pressure, is reached. If it does, the simple expedient of increasing the plate thickness will reduce the crystal strain and prevent breakage.

The gage sensitivity is high. The output is about one volt across 1000 micromicrofarads for a pressure of 10,000 psi.

AUTHOR INDEX

A

		Page
ABLARD, J. E.		
	Technical Note 1395	24
ALLGAIER, R. S.		
	NavOrd Report 2455	11
ADRIAN, F. J.		
	NavOrd Report 2608	17
ARONSON, C. J.		
	Technical Note 1501	25
	Technical Note 1649	28
ASTHEIMER, R. W.		
	NavOrd Report 2317	25
	Technical Note 1347	23
	Technical Note 1352	23
AUGUST, W. T.		
	NavOrd Report 2487	13
	NavOrd Report 2681	21

C

CHRISTIAN, E. A.		
	NavOrd Report 2277	3
	NavOrd Report 2317	4
	NavOrd Report 2368	5
	NavOrd Report 2437	9
	NavOrd Report 2462	12
	Technical Note 1227	22
COLEBURN, N. L.		
	NavOrd Report 2611	18

AUTHOR INDEX (cont'd)

C

	Page
CULLING, E. J.	
Technical Note 1501.....	25

D

DIMMOCK, W. E., Jr.	
NavOrd Report 2385.....	7
NavOrd Report 2494.....	13

E

EDWARDS, P. L.	
NavOrd Report 2380.....	6
NavOrd Report 2698.....	21
A High Speed High Pressure Gage..	31

F

FELDMAN, H. P.	
NavOrd Report 2625.....	18
FISCHER, M. J.	
NavOrd Report 1804.....	2
FISHER, E. M.	
NavOrd Report 2348.....	5
NavOrd Report 2584.....	15
Technical Note 1779.....	28

G

GALLOWAY, V. H.	
NavOrd Report 2484.....	23
GOERTNER, J. A.	
NavOrd Report 2277.....	3
NavOrd Report 2368.....	5
NavOrd Report 2553.....	15
NavOrd Report 2575.....	15

AUTHOR INDEX (cont'd)

H

		Page
HAMPTON, L. D.		
	NavOrd Report 2375	6
	NavOrd Report 2385	7
	NavOrd Report 2450	10
	NavOrd Report 2614	18
	NavOrd Report 2630	19
HARTMANN, G. K.		
	NavOrd Report 2451	10
HILL, M. E.		
	NavOrd Report 2497	14
	NavOrd Report 2600	17

J

JENSEN, D. W.		
	NavOrd Report 2394	8
	NavOrd Report 2498	14
	Technical Note 821	22
	Technical Note 1784	28
JOHNSON, O. H.		
	NavOrd Report 2448	10

K

KALAVSKI, P. Z.		
	NavOrd Report 2167	3
	NavOrd Report 2451	10

L

LEVY, J. B.		
	NavOrd Report 2313	4
	NavOrd Report 2608	17
	NavOrd Report 2696	21

AUTHOR INDEX (cont'd)

L

Page

LEVY, J. B.
Kinetics of Decomposition of Nitrate Esters. I. Ethyl Nitrate..... 31

LEWIS, J. B.
NavOrd Report 2596..... 16

LONG, A. O.
NavOrd Report 2480..... 12

LOVENBERG, C. C.
NavOrd Report 2370..... 6
NavOrd Report 2384..... 7
NavOrd Report 2589..... 16

LIDDIARD, T. P.
NavOrd Report 2611..... 18

M

MAROPIS, N.
Technical Note 1495..... 25

McGILL, R.
NavOrd Report 2339..... 5
NavOrd Report 2579..... 15

MEYER, K.
NavOrd Report 2644..... 19

MOULTON, J. F.
Technical Note 1501..... 25

AUTHOR INDEX (cont'd)

N

Page

NIFFENEGGER, C. R.
NavOrd Report 2553..... 15
Technical Note 1250..... 22
Technical Note 1322..... 22

P

PETES, J.
Technical Note 1501..... 25

PRICE, D.
NavOrd Report 2322..... 5
NavOrd Report 2445..... 9
NavOrd Report 2596..... 16
NavOrd Report 2673..... 20

Q

QUICK, R. G.
NavOrd Report 2301..... 4

R

ROSEN, J. M.
NavOrd Report 2484..... 13

ROSENBAUM, J. H.
NavOrd Report 2383..... 6
NavOrd Report 2436..... 9
Technical Note 1332..... 23

S

SAVITT, J.
NavOrd Report 2369..... 5
NavOrd Report 2442..... 9

AUTHOR INDEX (cont'd)

S

		Page
SAVITT, J.		
	Propagation of Explosive Produced Air Shocks.....	29
	Recent Air Shock Velocity Measurements Near Detonating Explosives.....	30
	Spalling Produced by Detonation of Explosives in Very Heavy Walled Metal Tubes.....	31
SHAPIRO, N.		
	Technical Note 1380.....	23
SICKMAN, D. V.		
	Technical Note 1636.....	26
SLIE, W. M.		
	NavOrd Report 2422.....	8
SLIFKO, J. P.		
	NavOrd Report 2277.....	3
	NavOrd Report 2368.....	5
	NavOrd Report 2553.....	15
SNAY, H. G.		
	NavOrd Report 1804.....	2
	NavOrd Report 2383.....	6
	NavOrd Report 2436.....	9
	NavOrd Report 2437.....	9
	NavOrd Report 2462.....	12
	Technical Note 1331.....	23
	Technical Note 1332.....	23
SOLEM, A. D.		
	NavOrd Report 2487.....	13
	NavOrd Report 2681.....	21
	Technical Note 1380.....	23
	Technical Note 1511.....	25

AUTHOR INDEX (cont'd)

S

		Page
STARR, L. E.		
	NavOrd Report 2369	5
	NavOrd Report 2385	7
	Spalling Produced by Detonation of Explosives in Very Heavy Walled Metal Tubes	31
STRESAU, R. H. F.		
	NavOrd Report 2422	8
	NavOrd Report 2442	9
	NavOrd Report 2460	11
	NavOrd Report 2644	19
	Low Velocity Detonation of Certain Primary Explosives	30
	Recent Air Shock Velocity Measurements Near Detonating Explosives	30
SVADEBA, G.		
	NavOrd Report 2384	7
	NavOrd Report 2433	8
	NavOrd Report 2614	18
	NavOrd Report 2647	20
SWIFT, E., Jr.		
	NavOrd Report 2277	3
	NavOrd Report 2317	4
	NavOrd Report 2575	15

T

TAYLOR, F., Jr.		
	NavOrd Report 2468	12
	Technical Note 1409	24

AUTHOR INDEX (cont'd)

V

Page

VARWIG, R. L.
Technical Note 1617..... 26

W

WINTERMOYER, J. P.
NavOrd Report 2496..... 13

Y

YOUNG, G. A.
NOLR 1169..... 28

SUBJECT INDEX

A

Page

Accelerometer calibration
NavOrd Report 2301..... 4

Accelerometers, horizontal and vertical
NavOrd Report 2301..... 4

Air Blast
Technical Note 1250..... 22

Air Blast, electro-kinetic gages
Technical Note 1495..... 25

Air Blast, gages
Technical Note 1495..... 25

Air Blast measuring systems, frequency response
Technical Note 1649..... 28

Air Blast velocity
NavOrd Report 2167..... 3

Aluminized explosives (see explosives, aluminized)

Ammonium perchlorate explosives
NavOrd Report 2553..... 15
NavOrd Report 2589..... 16

Analysis, qualitative
NavOrd Report 2484..... 13

Atomic explosions
Technical Note 1501..... 25

B

Base surge
NOLR 1169..... 28

SUBJECT INDEX (cont'd)

B

Page

Booster explosives
NavOrd Report 2448..... 10
Technical Note 1322..... 22

Brisance
NavOrd Report 2369..... 5
NavOrd Report 2385..... 7
NavOrd Report 2422..... 8

BTNEN
NavOrd Report 2384..... 7

Bubble energy
NavOrd Report 2277..... 3
NavOrd Report 2317..... 4
NavOrd Report 2368..... 5
NavOrd Report 2553..... 15
NavOrd Report 2575..... 15
Technical Note 1227..... 22

Bubble periods
NavOrd Report 2277..... 3
NavOrd Report 2317..... 4
NavOrd Report 2368..... 5
NavOrd Report 2553..... 15
NavOrd Report 2575..... 15
Technical Note 1227..... 22

Bubble pulse parameters
NavOrd Report 2277..... 3

Bubble pulse pressure
Technical Note 1227..... 22

Bubble theory
NavOrd Report 2277..... 3
NavOrd Report 2437..... 9

Burst curves, height
NavOrd Report 2451..... 10

SUBJECT INDEX (cont'd)

B

Page

Burst, optimum height
NavOrd Report 2451..... 10

tert-Butyl nitrate, decomposition
NavOrd Report 2608..... 17

C

Carbon dioxide, P-V-T data
NavOrd Report 2673..... 20

Charge weight relations
Technical Note 1649..... 28

Circuits, firing
NavOrd Report 2167..... 3

Composition B
NavOrd Report 2348..... 5

Compressor, NOL adiabatic
NavOrd Report 2455..... 11
NavOrd Report 2596..... 16

"Cover effect"
NavOrd Report 2584..... 15

Craters
NOLR 1169..... 28

Cyclotol, aluminized
NavOrd Report 2348..... 5

D

Damage theory
NOLR 1169..... 28
NavOrd Report 2462..... 12
NavOrd Report 2451..... 10

SUBJECT INDEX (cont'd)

D

Page

DATT
NavOrd Report 2375..... 6
NavOrd Report 2630..... 19

Dent test
NavOrd Report 2422..... 8

Detonation, propagation of
NavOrd Report 2385..... 7

Detonation velocity
NavOrd Report 2450..... 10
NavOrd Report 2460..... 11
NavOrd Report 2611..... 18
Low Velocity Detonation of Certain Primary Explosives... 30

Detonation velocity, binary explosives
NavOrd Report 2630..... 19

Detonation velocity, small scale
NavOrd Report 2450..... 10
NavOrd Report 2630..... 19

1,7-Diamyloxy-2,4,6-trinitro-2,4,6-triazheptane (DATT)
NavOrd Report 2375..... 6
NavOrd Report 2630..... 19

Diethyl peroxide, thermal decomposition
NavOrd Report 2696..... 21

1,7-Dimethoxypentamethylene-2,4,6-trinitro-2,4,6-triazaheptane (DMTT)
NavOrd Report 2375..... 6
NavOrd Report 2630..... 19

2,3-Dimethyl-1,3-dinitropropane
Technical Note 821..... 22

N,N'-Dinitrodimethyloxamide
Technical Note 1784..... 28

1,1-Dinitroethane
NavOrd Report 2448..... 10

SUBJECT INDEX (cont'd)

D

Page

Dinitroneopentane
Technical Note 821..... 22

4,4-Dinitropentanoic acid
NavOrd Report 2498..... 14

2,2-Dinitropropane
NavOrd Report 2370..... 6

2,2-Dinitro-1-propanol
NavOrd Report 2448..... 10

2,2-Dinitropropanol
NavOrd Report 2497..... 14

2,2-Dinitropropanol esters
NavOrd Report 2497..... 14

2,2-Dinotropropyl fumarate
NavOrd Report 2497..... 14

bis(2,2-Dinitropropyl)nitramine
NavOrd Report 2448..... 10

2,2-Dinitropropyl-4,4,4-trinitrobutyrate
NavOrd Report 2497..... 14

2,2-Dinitropropyl-N-trinitroethyl-N-nitraminoacelate
NavOrd Report 2497..... 14

1,9-Dinitroxypentamethylene-2,4,6,8-tetranitramine
NavOrd Report 2375..... 5

Diodes, gas filled voltage regulator, oscillations in
NavOrd Report 2698..... 21

DMTT
NavOrd Report 2375..... 6
NavOrd Report 2630..... 19

Dust deposits
NOLR 1169..... 28

SUBJECT INDEX (cont'd)

E

	Page
Emissivity of hot compressed gases	
NavOrd Report 2445	9
Emissivity of tungsten	
NavOrd Report 2445	9
Ethyl nitrate, decomposition	
NavOrd Report 2313	4
Kinetics of Decomposition of Nitrate Esters. I. Ethyl Nitrate	31
Ethyl nitrite, from thermal decomposition of ethyl nitrate	
NavOrd Report 2313	4
Explosion, ionization caused by	
NavOrd Report 2442	9
Explosion products	
NavOrd Report 1804	2
Explosion, underwater	
NavOrd Report 2277	3
NavOrd Report 2317	4
NavOrd Report 2368	5
NavOrd Report 2383	6
NavOrd Report 2436	9
NavOrd Report 2437	9
NavOrd Report 2462	12
NavOrd Report 2553	15
NavOrd Report 2575	15
Technical Note 1227	22
Technical Note 1250	22
Technical Note 1322	22
Explosion, underwater instrumentation	
NavOrd Report 2277	3
Explosions, atomic	
Technical Note 1501	25

SUBJECT INDEX (cont'd)

E

Page

Explosions, confined
NavOrd Report 2369..... 5
NavOrd Report 2385..... 7
NavOrd Report 2422..... 8
NavOrd Report 2442..... 9
Spalling Produced by Detonation of Explosives in Very Heavy Walled Metal Tubes..... 31

Explosions in air
NavOrd Report 2167..... 3
NavOrd Report 2348..... 5
NavOrd Report 2451..... 10
NavOrd Report 2584..... 15
Technical Note 1495..... 25
Technical Note 1501..... 25
Technical Note 1649..... 28
Technical Note 1779..... 28

Explosions, underground
NOLR 1169..... 28

Explosions, underground effects
NOLR 1169..... 28

Explosive trains
NavOrd Report 2385..... 7

Explosives, aluminized
NavOrd Report 2277..... 3
NavOrd Report 2317..... 4
NavOrd Report 2348..... 5
NavOrd Report 2368..... 5
NavOrd Report 2553..... 15
NavOrd Report 2611..... 18

Explosives analysis
NavOrd Report 2484..... 13

Explosives, binary, detonation velocity
NavOrd Report 2630..... 19

SUBJECT INDEX (cont'd)

E

Page

Explosives comparison
NavOrd Report 2277..... 3
NavOrd Report 2317..... 4
NavOrd Report 2348..... 5
NavOrd Report 2368..... 5
NavOrd Report 2553..... 15

Explosives containing aluminum, titanium, and zirconium
Technical Note 1331..... 23

Explosives containing chlorine and fluorine
Technical Note 1332..... 23

Explosives, desensitization
Technical Note 821..... 22

Explosives, DY-DX
NavOrd Report 2553..... 15

Explosives, equivalent volumes
NavOrd Report 2348..... 5

Explosives, equivalent weights
NavOrd Report 2348..... 5

Explosives evaluation, small scale
NavOrd Report 2375..... 6
NavOrd Report 2422..... 8
NavOrd Report 2450..... 10
NavOrd Report 2494..... 13
NavOrd Report 2630..... 19

Explosives, fuze components
Technical Note 1395..... 24

Explosives, military identification
NavOrd Report 2484..... 13

Explosives, optimum air blast mixture
NavOrd Report 2348..... 5

SUBJECT INDEX (cont'd)

E

Page

Explosives, primary
NavOrd Report 2460..... 11
NavOrd Report 2468..... 12
NavOrd Report 2644..... 19
NavOrd Report 2647..... 20
Technical Note 1395..... 24
Low Velocity Detonation of Certain Primary Explosives.. 30

F

Fuze components
Technical Note 1395..... 24

G

Gage calibration, air blast
Technical Note 1779..... 28

Gage, diaphragm
NavOrd Report 2317..... 4

Gages, air blast
Technical Note 1495..... 25

Gages, air pressure
Technical Note 1649..... 28

Gages, electro-kinetic air blast
Technical Note 1495..... 25

Gages, high speed, high pressure
NavOrd Report 2380..... 6
A High-Speed High-Pressure Gage..... 31

Gages, pressure, low impedance
Technical Note 1352..... 23

Gages, pressure, piezoelectric
NavOrd Report 2380..... 6

SUBJECT INDEX (cont'd)

G

Page

Gages, pressure, piezoelectric
Technical Note 1347..... 23

Gages, tellurium
Technical Note 1352..... 23

Gases, emissivity
NavOrd Report 2445..... 9

Gases, P-V-T data
NavOrd Report 2322..... 5
NavOrd Report 2673..... 20

GGE, (19% RDX; 28.5% TNT; 47.5% Al; 5% Wax)
NavOrd Report 2553..... 15

Ground accelerations
NavOrd Report 2301..... 4

Ground shock
NavOrd Report 2301..... 4

H

HBX
NavOrd Report 2277..... 3
NavOrd Report 2317..... 4
NavOrd Report 2348..... 5
NavOrd Report 2368..... 5
NavOrd Report 2553..... 15
NavOrd Report 2584..... 15
Technical Note 1227..... 22
Technical Note 1322..... 22

Heat capacities
NavOrd Report 1804..... 2

Heat of combustion
Technical Note 1636..... 26

SUBJECT INDEX (cont'd)

H

Page

Heat of formation
Technical Note 1636..... 26

Height of burst curves, optimum
NavOrd Report 2451..... 10

H-6
NavOrd Report 2348..... 5

I

Ice VII
NavOrd Report 2383..... 6

Initiation, perpherial
NavOrd Report 2681..... 21

Initiation time
NavOrd Report 2644..... 19

Ionization, caused by explosion
NavOrd Report 2442..... 9

Instrumentation
Technical Note 1347..... 23
Technical Note 1352..... 23

L

Lead azide
NavOrd Report 2442..... 9

M

Mercuric fulminate
NavOrd Report 2442..... 9

SUBJECT INDEX (cont'd)

M

Page

Meterological effects
NOLR 1169..... 28

N-Methyl-5-nitrotetrazole
NavOrd Report 2468..... 12

1-Methoxy-2,4,6-trinitro-2,4,6-triazaheptane (MTT)
NavOrd Report 2375..... 6

Micro-comparator
NavOrd Report 2625..... 18

Microcoulometer
Technical Note 1347..... 23

Mine laying hazards
Technical Note 1380..... 23
Technical Note 1511..... 25

Mines, premature detonation
Technical Note 1380..... 23
Technical Note 1511..... 25

MNO
Technical Note 1784..... 28

Mobile air blast laboratory, Stump Neck, Maryland
NavOrd Report 2167..... 3

Multi-vibrators, one shot
Technical Note 1617..... 26

N

Nitrate, esters of, thermal decomposition
NavOrd Report 2313..... 4
NavOrd Report 2608..... 17
NavOrd Report 2696..... 21
Kinetics of Decomposition of Nitrate Esters.
I. Ethyl Nitrate..... 31

SUBJECT INDEX (cont'd)

N

Page

Nitroethane, from decomposition of n-propyl nitrate
NavOrd Report 2608..... 17

Nitroform ion, ultraviolet spectrum
NavOrd Report 2480..... 12

5-Nitrotetrazole, metal salts of
NavOrd Report 2468..... 12

P

Pentaerythritol tetranitrate; PETN
Technical Note 1784..... 28

Pentolite, shape charge performance
NavOrd Report 2681..... 21

Pentolite, underwater explosion parameters
NavOrd Report 2575..... 15

Photographic records, analysis
NavOrd Report 2625..... 18

Plastic case charges
NavOrd Report 2584..... 15

Plate theory
NavOrd Report 2462..... 12

Polymethylenepolynitramines
NavOrd Report 2375..... 6

Pressures, near triple point
NavOrd Report 2451..... 10

Primary explosives (see explosives primary)

n-Propyl nitrate, thermal decomposition
NavOrd Report 2608..... 17

SUBJECT INDEX (cont'd)

R

Page

Radiation, black and gray body
NavOrd Report 2445 9

Record analysis
NavOrd Report 2317 4

Recording systems, high speed
NavOrd Report 2167 3

Reflecting surface
Technical Note 1779 28

Reflection, theory of regular
NavOrd Report 2451 10

Reports, abstracts of, Explosives Research Department 1951
NavOrd Report 2339 5

S

Safety, laboratory shields
Technical Note 1409 24

Sensitivity, booster
NavOrd Report 2370 6
NavOrd Report 2494 13
NavOrd Report 2589 16

Sensitivity, gap
NavOrd Report 2494 13

Sensitivity, impact
NavOrd Report 2433 8
NavOrd Report 2579 15
NavOrd Report 2647 20

Sensitivity, theory
NavOrd Report 2579 15

SUBJECT INDEX (cont'd)

S

Page

Sensitivity, various explosives
NavOrd Report 2579..... 15

Shaped charge penetration
NavOrd Report 2681..... 21

Shaped charges
NavOrd Report 2487..... 13
NavOrd Report 2681..... 21

Shaped charges, anti-tank weapons
NavOrd Report 2487..... 13

Shaped charges, effect of barriers on
NavOrd Report 2487..... 13

Shock conduction through gases
NavOrd Report 2385..... 7
NavOrd Report 2442..... 9

Shock front temperature
NavOrd Report 2383..... 6

Shock near explosions
NavOrd Report 2442..... 9

Shock tube photography
Technical Note 1617..... 26

Shock velocity in air
NavOrd Report 2370..... 6
NavOrd Report 2442..... 9
Technical Note 1250..... 22
Propagation of Explosive Produced Air Shocks..... 29
Recent Air Shock Velocity Measurements Near Detonating Explosives..... 30

SUBJECT INDEX (cont'd)

S

Page

Shock velocity in metals
NavOrd Report 2369..... 5
NavOrd Report 2385..... 7
Spalling Produced by Detonation of Explosives in Very Heavy Walled Metal Tubes..... 31

Shock velocity method
Technical Note 1779..... 28

Shock wave particle velocity
NavOrd Report 2383..... 6

Shock wave velocity
NavOrd Report 2383..... 6

Shock wave, underwater
NavOrd Report 2317..... 4
NavOrd Report 2368..... 5
NavOrd Report 2383..... 6
NavOrd Report 2462..... 12
NavOrd Report 2553..... 15
NavOrd Report 2575..... 15
Technical Note 1227..... 22

Silver 5-nitrotetrazole, crystal growth
NavOrd Report 2496..... 13

Silver 5-nitrotetrazole, properties
NavOrd Report 2496..... 13

Sound velocity
NavOrd Report 2383..... 6

Spin table calibrator, for accelerometers
NavOrd Report 2301..... 4

T

Temperature, measurement of by radiation
NavOrd Report 2445..... 9

SUBJECT INDEX (cont'd)

T

Page

Tetryl
Technical Note 1322..... 22

Thermodynamic functions of explosion products
NavOrd Report 1804..... 2

Time calibration
Technical Note 1617..... 26

Time delay, dual
NavOrd Report 2167..... 3

Titanium
Technical Note 1331..... 23

Transducer, piezoelectric high pressure
NavOrd Report 2380..... 6

2,2,2-Trinitroethanol
NavOrd Report 2498..... 14
NavOrd Report 2600..... 17

5-Trinitroethylaminotetrazole
NavOrd Report 2468..... 12

2,2,2-Trinitroethyl, detonation velocity
NavOrd Report 2614..... 18

2,2,2-Trinitroethyl 3,5-dinitrobenzoate
NavOrd Report 2600..... 17

2,2,2-Trinitroethyl esters
NavOrd Report 2600..... 17

2,2,2-Trinitroethyl 4,4-dinitropentonoate
NavOrd Report 2498..... 14

2,2,2-Trinitroethyl fumarate
NavOrd Report 2600..... 17

SUBJECT INDEX (cont'd)

T

	Page
Bis(trinitroethyl)nitramine NavOrd Report 2384	7
Bis(trinitroethyl)nitramine, decomposition NavOrd Report 2394	8
2,2,2-Trinitroethyl succinate NavOrd Report 2600	17
2,2,2-Trinitroethyl 4,4,4-trinitrobutyrate NavOrd Report 2614	18
2,2,2-Trinitroethyl 4,4,4-trinitrobutyrate evaluation NavOrd Report 2614	18
2,2,2-Trinitroethyl 4,4,4-trinitrobutyrate sensitivity NavOrd Report 2614	18
TNT NavOrd Report 2348	5
Tritonal NavOrd Report 2348	5
Tubes, voltage regulator, oscillations in NavOrd Report 2698	21

U

Underwater bubble measurements NavOrd Report 2277	3
Underwater explosions (see explosion underwater)	
Underwater shock wave (see shock wave underwater)	

SUBJECT INDEX (cont'd)

V

Page

Van der Waals Laboratory, equipment and program
NavOrd Report 2322..... 5

Voltage regulators, oscillations in tubes
NavOrd Report 2698..... 21

W

Warheads, torpedo
Technical Note 1322..... 22

Water, P-V-T data
NavOrd Report 2673..... 20

Wax, explosive
Technical Note 821..... 22